73rd MORSS CD Cover Page

UNCLASSIFIED DISCLOSURE FORM CD Presentation

712CD

21-23 June 2005, at US Military Academy, West Point, NY

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Name of Principal Author and all other author(s):
Mr. Andy Phend (P), Mr. Joseph D. Fann, Mr. Steve Glasgow, Mr. Jeff Franssen

Principal Author's Organization and address:
Teledyne Brown Engineering, Inc.
300 Sparkman Drive
Huntsville, AL, 35805

Phone: **256.726.1791**

Fax: **256.726.2241**

Email: **andy.phend@tbe.com**

Original title on 712 A/B: **Implementation of Space-Based Radar (SBR) Functionality in the Advanced Warfighting Simulation (AWARS)**

Revised title:_____

Presented in (input and Bold one): (WG **5** , CG___, Special Session ___, Poster, Demo, or Tutorial):

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Army Space and Missile Defense Command

Implementation of Space-Based Radar (SBR) Functionality in the Advanced Warfighting Simulation (AWARS)

73rd MORS Symposium
21-23 June 2005

Andrew E. Phend
Teledyne Brown Engineering
300 Sparkman Drive
Huntsville, Alabama 35805
256.726.1791
andy.phend@tbe.com

Steven R. Elliott
US Army Space and Missile Defense Command
PO Box 1500
Huntsville, AL. 35807-3801
(256)955-5315 DSN 645-5315
steven.r.elliott@us.army.mil

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Report Documentation Page

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2005	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Implementation of Space-Based Radar (SBR) Functionality in the Advanced Warfighting Simulation (AWARS)	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
Teledyne Brown Engineering 300 Sparkman Drive Huntsville, Alabama 35805	

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM201946, Military Operations Research Society Symposium (73rd) Held in West Point, NY on 21-23 June 2005. , The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**28**	

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AWARS/SBR Integration

Background

Space FACT (Focus Area Collaborative Team) Roadmap

FACT Submitted Project through AMIP/SIMTECH Program

Funded by Army Modeling and Simulation Office (AMSO)

Combined Effort
US Army TRADOC Analysis Center
US Army SMDC

The Team

AWARS PM,
Terry Gach
Technical Lead,
Steve Glasgow

Technical Management,
Jeff Franssen
Steve Elliott

Contract Support:
Teledyne Brown Engineering
Technical Lead: Andy Phend
Dynetics, Inc.
Technical Lead: Joey Fann

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What is AWARS?

- **Multi-sided, CORPS-Division level model**

- **Deterministic**

- **Aggregate corps-company resolution**

  - **May use single entity units in special cases**

- **C2 based**

  - **Everything is tied to the plan**

  - **Decisions are based on reports**

  - **Communications are passed out via appropriate channels**

  - **Memory exists for various report fields**

- **Perception is the key**

 - **Decisions based on perceived knowledge base**

  - **Engagements based on perception**

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What is Space-Based Radar?

- A constellation of satellites designed to provide a desired degree of global coverage.

- A radar sensor on each satellite in the constellation.

- A ground element providing telemetry, tracking, command and control of the satellite constellation, mission scheduling for the radars, and receipt and signal processing of the mission data collected.

- A communications architecture supporting the interfaces and data transmission requirements.
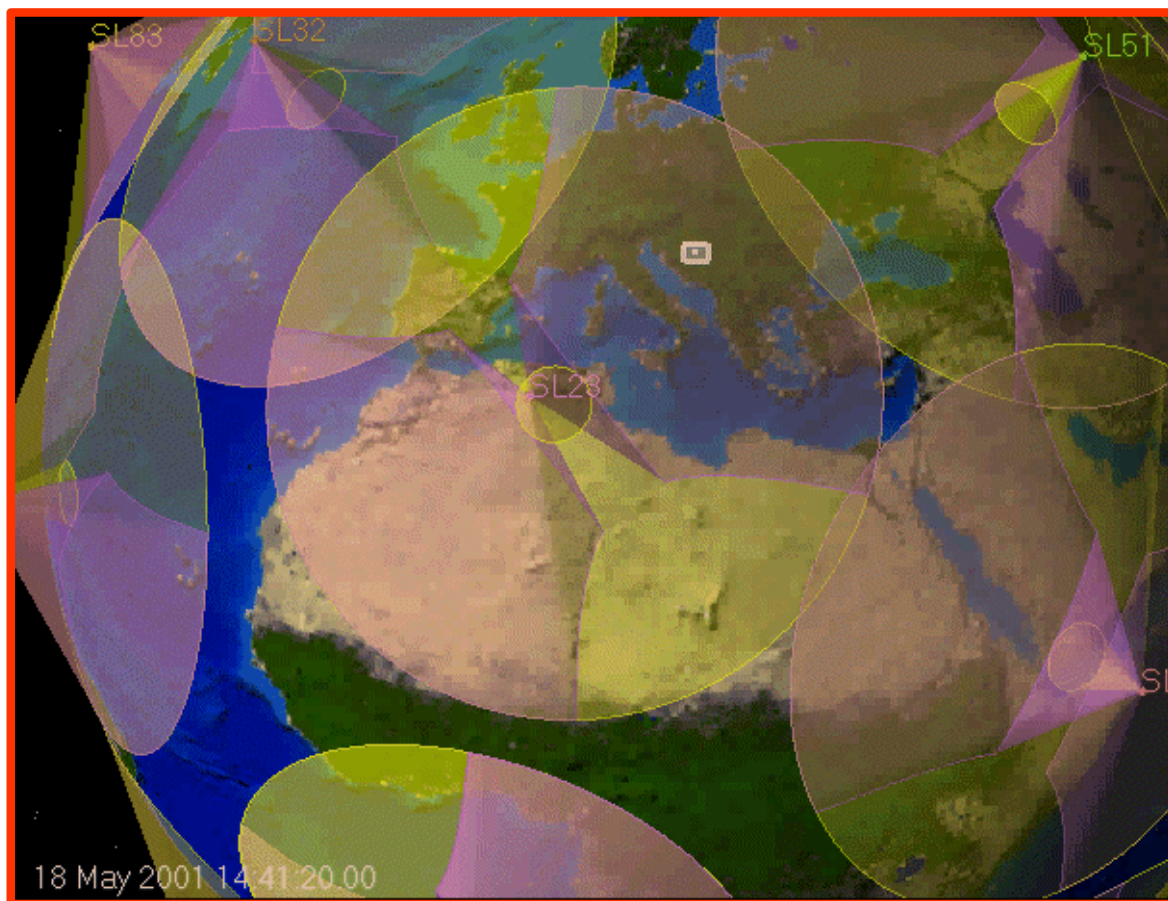
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Development Scope

- **Provide the AWARS model with an SBR capability to be used in future analysis studies**

- **Implementation required the development of five different modules**

  - **Schedule Manager**

  - **Mission Scheduler**

  - **Collection Controller**

  - **Collection Processor**

  - **HLA Interface**

- **All five modules working together in an event-driven environment provide SBR functionality in AWARS**
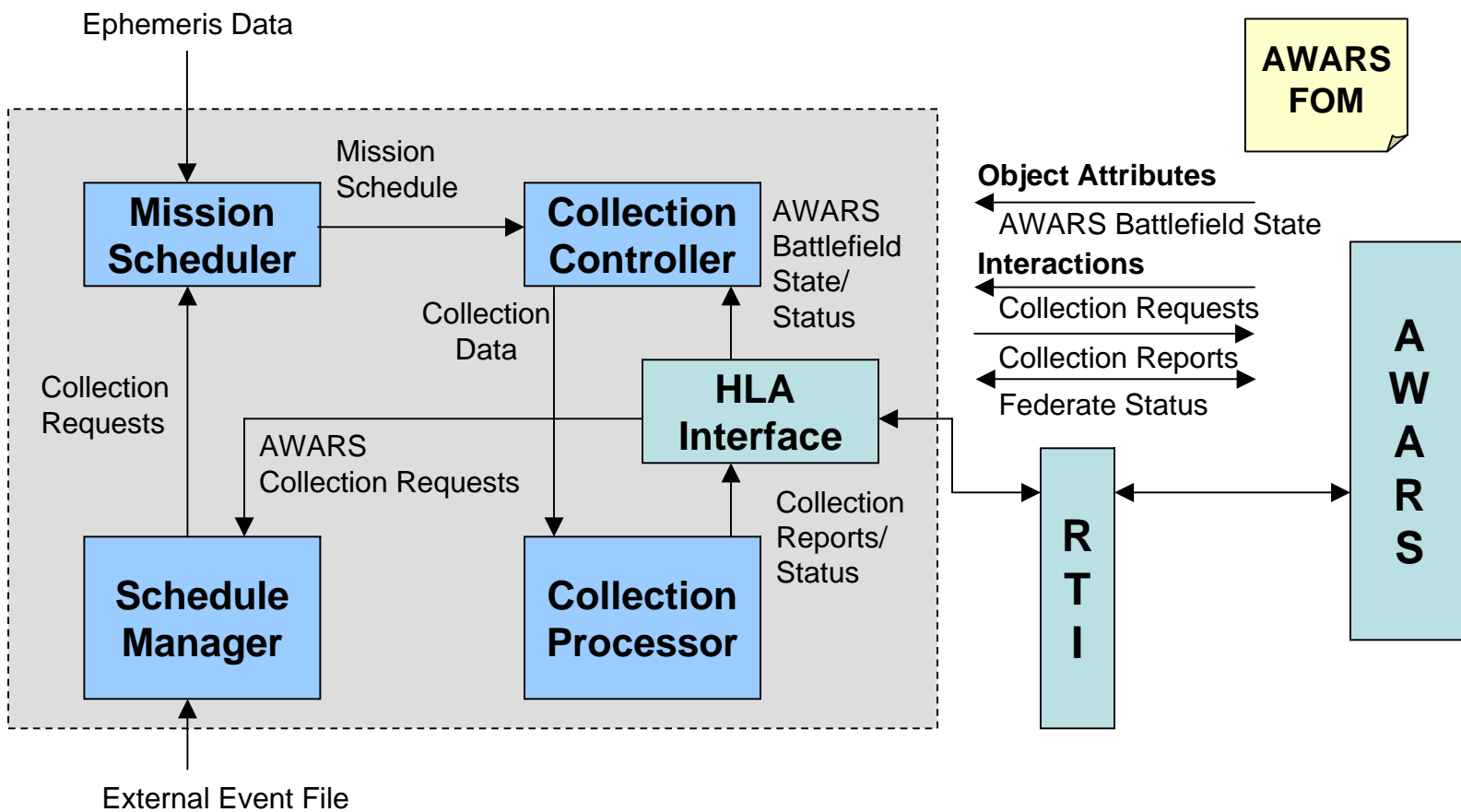
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AWARS/SBR System Architecture

Ephemeris Data

AWARS FOM

Mission Schedule

Mission Scheduler

Collection Controller

AWARS Battlefield State/ Status

Object Attributes

AWARS Battlefield State

Interactions

Collection Requests

Collection Data

Collection Reports

Federate Status

Collection Requests

HLA Interface

AWARS Collection Requests

Schedule Manager

Collection Reports/ Status

Collection Processor

R T I

A W A R S

External Event File

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Schedule Manager

Construct/modify the scheduler inputs to accommodate ad hoc/time sensitive collection requests from AWARS and surveillance collection requests from the external event file

- **Continuously merges collection requests from external event file and ad hoc requests from AWARS into a repository of collection requests**

- **Prepares the list of collection requests available for each planning interval**

- **Sends the list of requests to the mission scheduler for scheduling**

- **Holds/Retains all requests not scheduled**

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Mission Scheduler

Generate a collection schedule for a routine planning cycle (a specified, fixed time period, i.e. 24 hours)

- Originally designed to be a third-party GOTS scheduler, eventually became an internal SBR element

- The SBR module acquires satellite positions from ephemeris data files generated from third-party satellite propagation tools or, internally, from the SBR satellite propagation algorithm component

- Given a list of collection requests and satellite positions, generate the mission schedule for the SBR for a given planning period

- Sends the mission schedule to collection controller for execution

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Satellite Constellation Construction

Two complementary approaches to satellite modeling

1. **Satellite propagation algorithm component of the SBR module**

   - Circular constellations defined by number of planes, satellites per plane, altitude, inclination, starting phase, and starting Right Ascension of Ascending Node (RAAN)

   - Satellite positions determined at SBR module initialization with location of first satellite determined by starting phase and RAAN, and all others spaced evenly throughout planes

   - Easily create a variety of constellation options

   - Generate representative visibility statistics (battlefield and NAI)

   - Allow users without third-party tool to use the AWARS/SBR module

2. **Load ephemeris data generated by third-party satellite propagators**

   - Represent of any number of satellites in any type of orbit

   - Allows the composition of a variety of orbit types
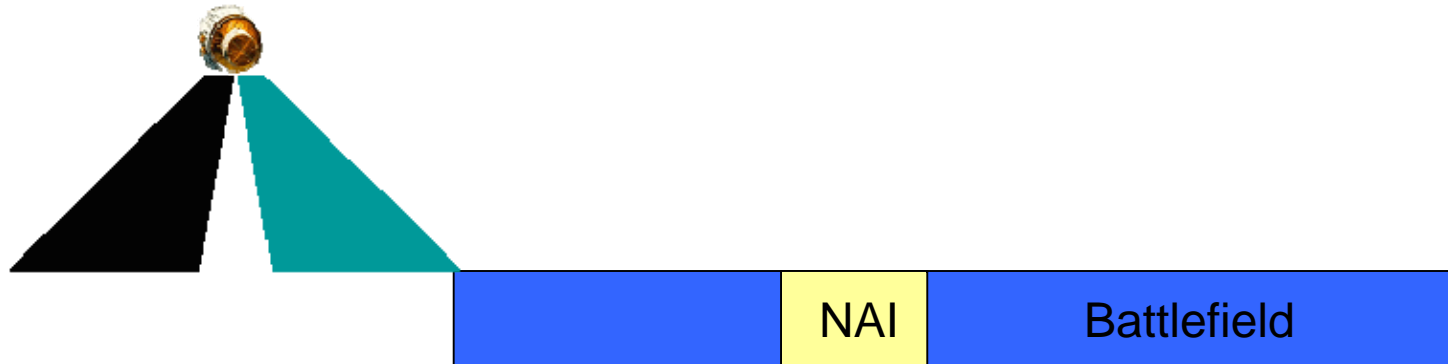
   - Users can generate ephemeris data from the tool they trust

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Satellite Visibility

- A satellite pass is defined as the time a satellite can see any part of the battlefield

- An NAI viewable window is defined as the time a satellite can see the entire NAI

| NAI | Battlefield |

start of satellite pass

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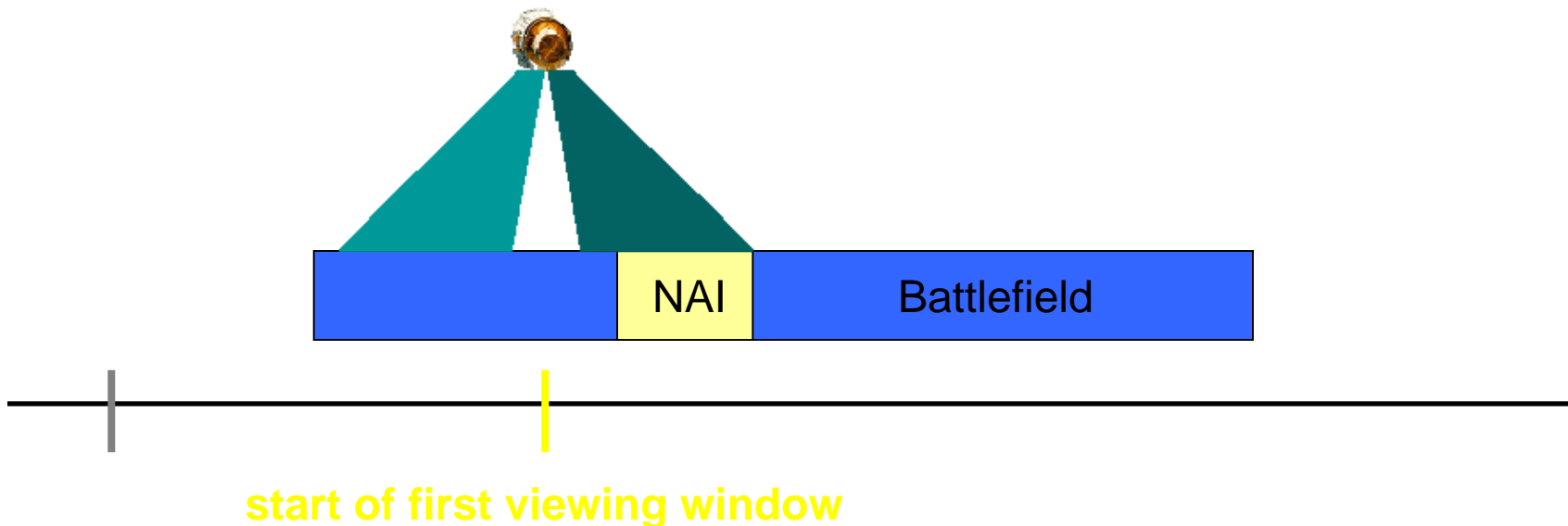
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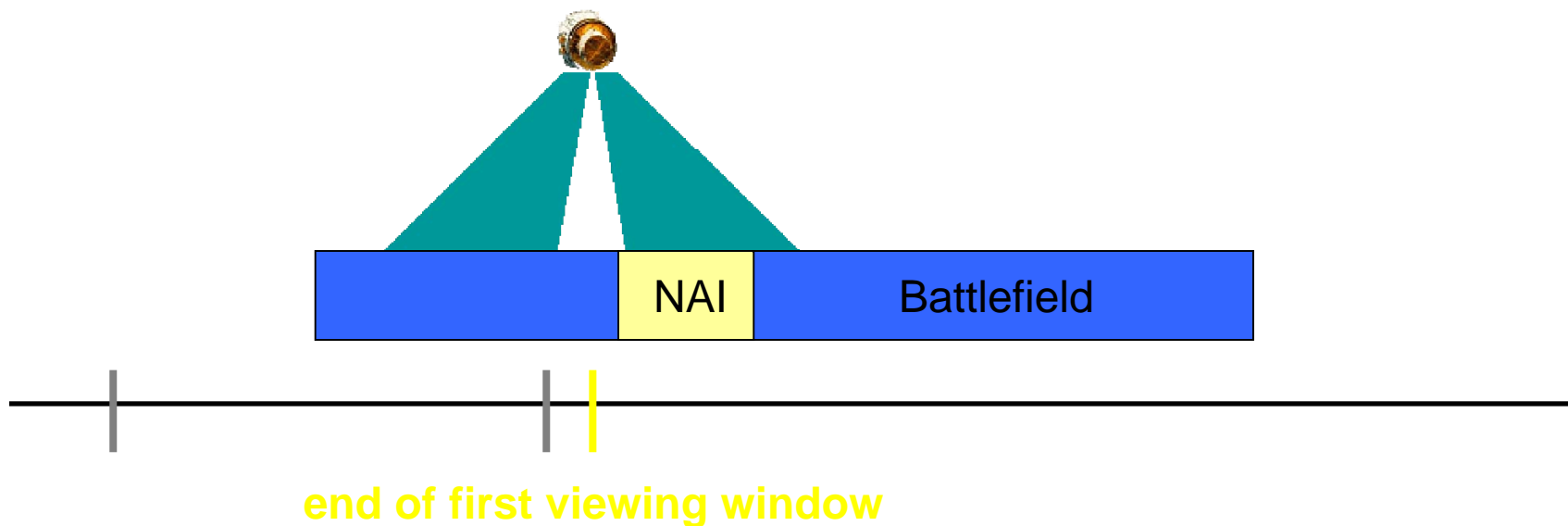| NAI | Battlefield |

start of first viewing window

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Satellite Visibility

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end of first viewing window

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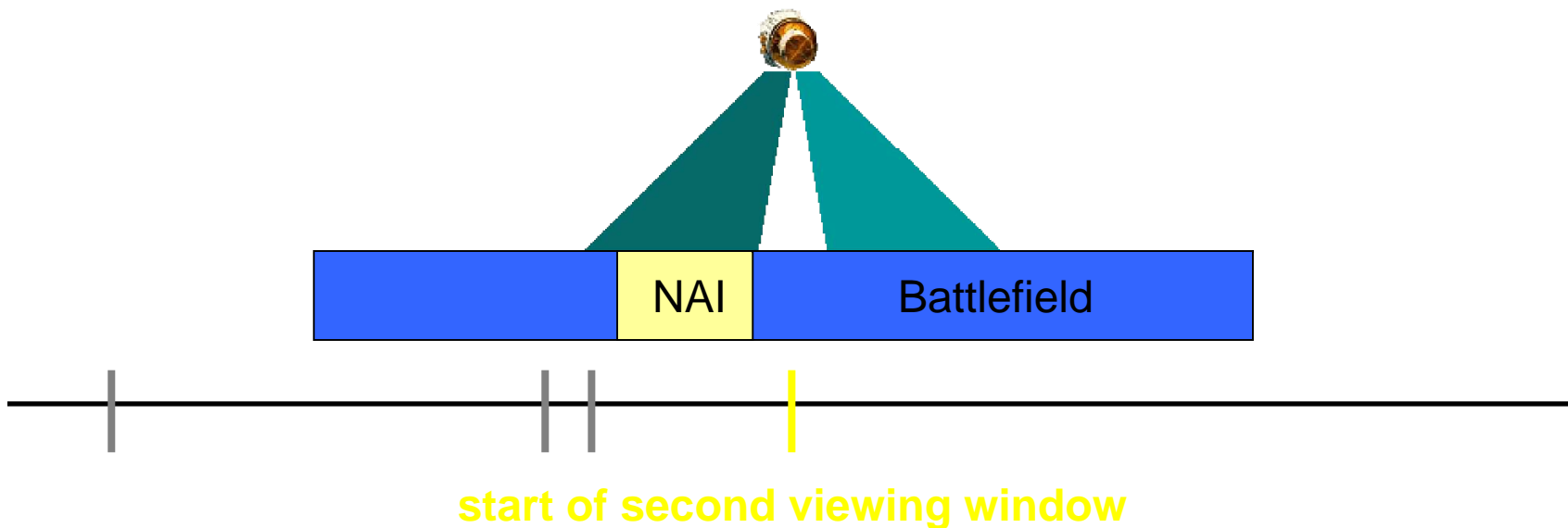

start of second viewing window

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Satellite Visibility

- A satellite pass is defined as the time a satellite can see any part of the battlefield

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NAI Battlefield

end of second viewing window

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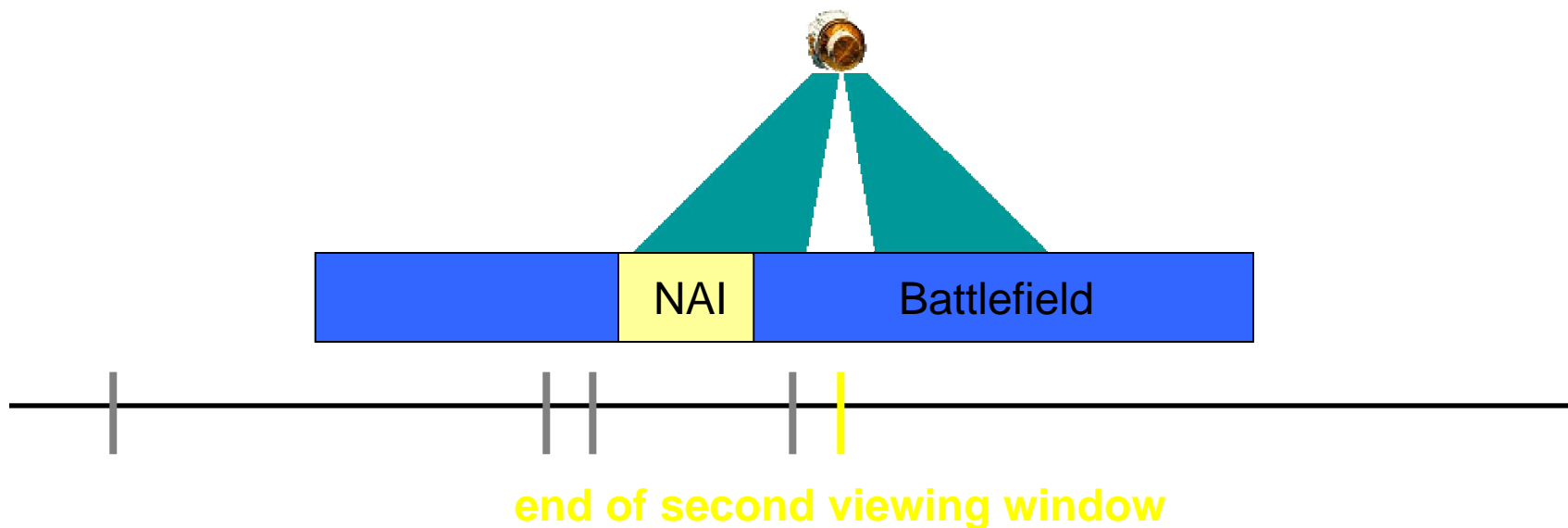
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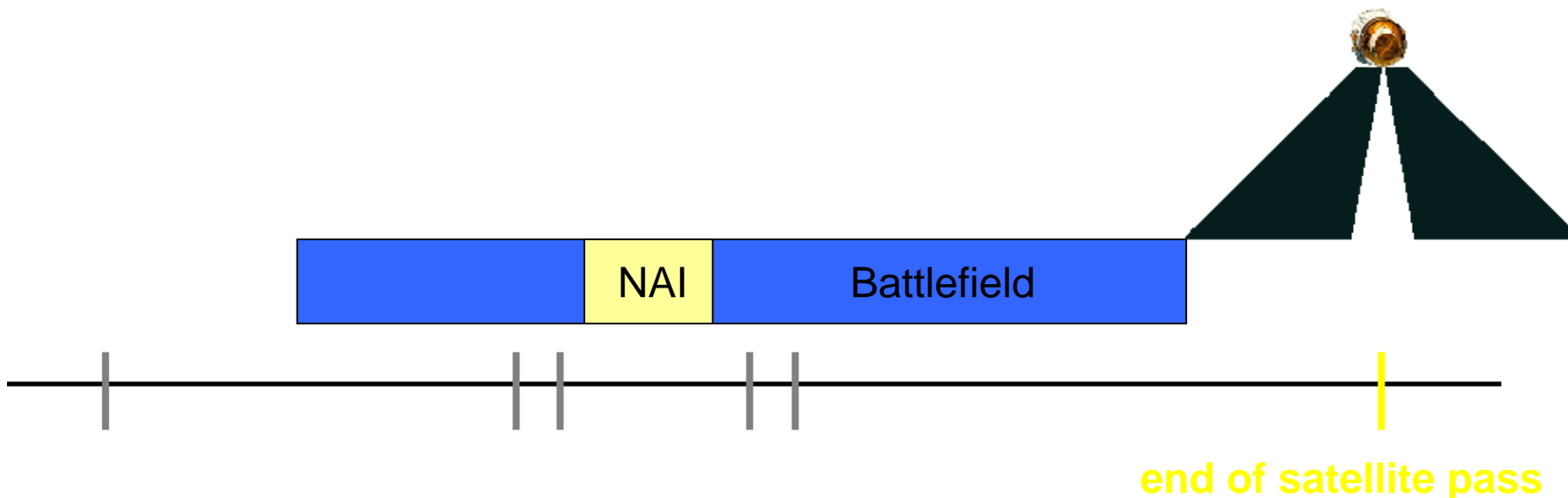

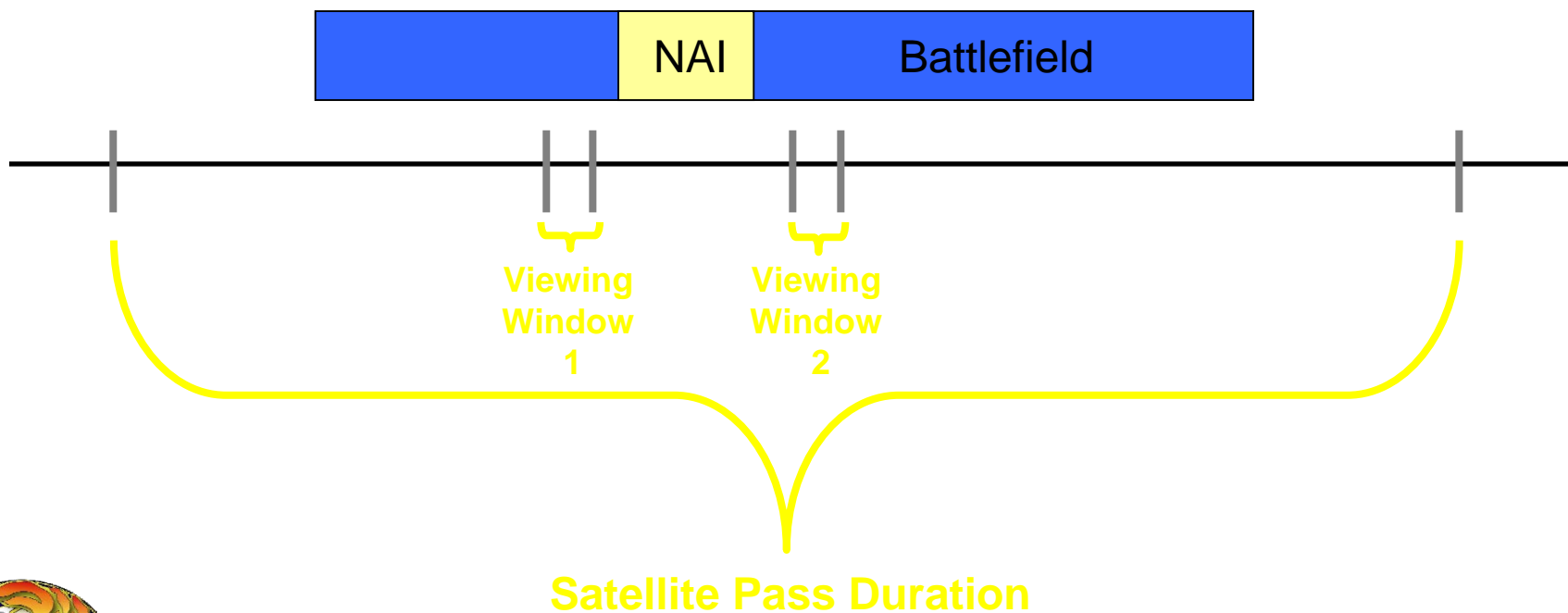**end of satellite pass**

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Satellite Visibility

- A satellite pass is defined as the time a satellite can see any part of the battlefield

- An NAI viewable window is defined as the time a satellite can see the entire NAI

NAI	Battlefield

Viewing Window 1

Viewing Window 2

Satellite Pass Duration

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Scheduling Requests

- The mission schedule consists of a series of sequential satellite passes and viewing windows over the battlefield

- For each planning period, every available satellite pass is scheduled individually and then stored

- GMTI scans are scheduled first, followed by SAR scans

- When all satellite passes for a planning period have been scheduled, the mission schedule is passed to the collection controller

- Ad hoc requests are scheduled on the first available unscheduled satellite pass

- The mission scheduler will continue to generate mission schedules until the end of the simulation

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Collection Controller

Execute the planned mission schedule and pass appropriate data to the collection processor for exploitation and report generation

- Represents a constellation of SBR satellites defining the robustness of the modeled system

- Contains all characteristics necessary to define the SBR sensors in the model

- Gathers collection data using the mission schedule, the current simulation time, and the battlefield state at that time

- Collection data passed to the collection processor for processing

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Collection Processor

Process Synthetic Aperture Radar (SAR) collection data and Ground-Moving Target Indicator (GMTI) collection data, generate collection reports, and transmit the reports to AWARS

- The collection processor uses the collected data and determines platform detections

- Collection reports are generated, detailing the platform detections

- The collection processor sends collection reports to AWARS model using the HLA Interface

- The reports generated by the collection processor represent the only output provided to the AWARS model from the SBR implementation

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SBR SAR Radar Implementation

- A radar mapping technique for generating high-resolution images of surface targets and the surrounding terrain

- Model based on a focused, pulsed radar with non-coherent integration, typical of a space-based sensor system

- Due to future AWARS capability expansion, SAR image sensor fusion node located in AWARS for image exploitation

- SBR performs the sensor collection and builds a representative truth image of the requested battlefield area

- Configurable by the user to provide a flexible framework for the representation of a space-based SAR sensor

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SBR GMTI Radar Implementation

- Designed to detect and retain signals from moving ground targets

- Utilizes an effects-based modeling approach to implement the GMTI sensor modeling

- SBR federate retrieves the current location of the sensor in relation to the target and, based on the representative radar sensor parameters and radar range equation, performs an adjusted sensor collection

- Data is processed and detections are computed based on representative sensor input data

- False alarms are computed based on the detections and the probability of false alarm

- Configurable by the user to provide a flexible framework for the representation of a space-based GMTI sensor

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HLA Interface

Provides the external simulation communication between AWARS and the SBR Federate

- **Utilizes the HLA Standard Version 1.3**

- **Implemented an AWARS/SBR Federation Object Model (FOM) developed specifically for this implementation.**

    - **Battlefield Objects provided by AWARS**

    - **Request & Report Interactions generated by both Federates**

    - **Utility Interactions defined to perform specific functions**

- **Implements RTI services from the "main" service groups including Federation Management, Declaration Management, and Object Management.**

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RTI Service Implementation

- **AWARS utilizing VTC RTI NG Version 1 series**

- **SBR Team utilizing DMSO RTI NG Version 6**

- **Typical Federation, Declaration, Object Management Services**

- **Time Management**
  - **Performed quick analysis to determine need for HLA**
  - **Time Management Services**
  - **AWARS "Real-Time" execution capability deciding factor**

- **Synchronization Points**

  - **Determined interaction approach more feasible given development schedule constraints**

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First Integration Event

The First Integration Event occurred on-site at TRAC the week of December 13-17, 2004. The objective of the event was to perform initial setup and integration activities in preparation to begin testing of the AWARS/SBR simulation interface.

- **No issues regarding RTI versions (none expected)**

- **FOM basic structure remained unchanged**
    - **Attributed to consistent communication**

- **Federate Status Interaction Added**
    - **Execution phase reporting**
    - **Cancel collection request**

- **Federation initialization and execution procedures established**

- **Request/Report Interactions successfully tested**

- **Few data encoding issues resolved quickly**

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Second Integration Event

The Second (and final) Integration Event occurred on-site at TRAC the week of February 1-4, 2005. The objective of this follow-on event was to complete simulation integration activities focusing on the generation and receipt of HLA object attribute updates.

- **Battlefield object structure tested for first time**
    - AWARS reporting at sub unit level with platform information
    - Platform Attribute implemented as variable length list

- **SBR received Attribute updates from AWARS to populate scenario battlefield**

- **SBR performed sensor collections based on input files and dynamic AWARS collection requests**

- **SBR generated collection reports for both SAR and GMTI requests and successfully sent them to AWARS**

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Project Accomplishments

➤ Developed an independent and extensible space-based sensor simulation that provides the capability to dynamically model satellite constellations, associated sensors, and Command & Control (C2) functions.

➤ Confirmed the technical viability of the project objective to integrate SBR functionality within AWARS utilizing the HLA as the simulation integration architecture

➤ Applied a tailored federation development process to ensure the timely specification of the HLA FOM and RTI service implementation to facilitate simulation interoperability.

➤ Demonstrated the success of a combined effort between the Space and Missile Defense Command (SMDC) and the Training Doctrine Command (TRADOC) Analysis Center (TRAC).

➤ Produced a reliable AWARS/SBR federation implementation upon which advanced Intelligence, Surveillance, and Reconnaissance (ISR) studies and analysis can be performed.

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Acknowledgements

SMDC Future Warfare Center:

    Mr. Steve Elliott

    Mr. Jeff Franssen

    Mr. Justin Novak

TRADOC Analysis Center:

    Mr. Terry Gach

    Mr. Steve Glasgow

    Mr. Robert Horton